



USAF PRAM PROGRAM FINAL REPORT



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P R A M P R O G R A M O F F I C E

F-15 FUEL TANK SEALANT

Warner Robins Air Logistics Center
F-15 System Program Office
WR-ALC/LF

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MICHAEL C. KOSTELNIK, Colonel, USAF
Vice Commander
Warner Robins Air Logistics Center
Robins Air Force Base, Georgia

PRAM Project No: 14990-01
Tab Number: 7017
Project Officer: Mr Scott Mangrum
Office Symbol: WR-ALC/LFEFS
Telephone No: DSN 468-5434

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1. EXECUTIVE SUMMARY

The F-15 wing is a source of constant maintenance because of chronic, recurring leaks from the integral fuel tank. F-15 engineering has evaluated several different concepts, in parallel with this PRAM project, to determine the most effective methods in eliminating this problem.

This PRAM project involved applying an Improved Sealing Process (ISP), developed by McDonnell Douglas, to the inside of the integral wing tank. The process applied a sprayable sealant barrier along with the existing channel groove seal. Unlike a bladder, this sealing process covers only potential leak paths such as fasteners and structural joints. The total project cost was \$152,300.

Other efforts initiated in conjunction with the PRAM project included implementing a similar sealant barrier applied with a brush, specifying an improved channel groove sealant, and completely revising the integral wing fuel tank sealing technical data.

The ISP process was prototyped at Warner Robins on four programmed depot maintenance (PDM) wings. The ISP was successfully prototyped, and the wings were placed in service on four separate aircraft.

The aircraft were evaluated in the field for approximately 1 year, and the results indicated leaks on all wings. There was no conclusive evidence showing that the ISP was significantly better than conventional sealing methods.

With the test results being less than desired, implementation is not recommended due to the limited benefits of the ISP being greatly outweighed by the cost of equipment, facility allocation, environmental concerns, and PDM schedule impact.

2. INTRODUCTION

The F-15 integral wing fuel tank sealing system uses a peripheral channel groove injected with a noncuring flourosilicone sealant. There are several potential leak scenarios commonly associated with this system that include different swell rates of fuel/channel groove sealant combinations, improper injection and maintenance of the channel groove sealing system, incomplete and confusing technical data, and flexure of the wing structure. The F-15 maintainers have addressed their serious concerns regarding these fuel leaks at the annual F-15 APG Product Improvement Working Group (PIWG). McDonnell Douglas also realized that the channel groove system required improvement to provide a higher degree of reliability. The resulting effort was a McDonnell Douglas funded Independent Research and Development (IRAD) project to develop a sprayable fuel tank sealing system. The testing of this work was accomplished at Wright Labs, Wright-Patterson AFB, Ohio, and was successfully prototyped on the Blue Angels' F-18 oil tanks.

F-15 engineering received an unsolicited report from McDonnell Douglas to use this newly developed sealing process. This process appeared to be a low risk attempt at solving the F-15 wing leak problem. Since the majority of the initial testing work had been accomplished at Wright Labs, they were contacted, and it was agreed that they would pursue this as a PRAM project and hand off the project to Warner Robins upon PRAM approval. McDonnell Douglas was put on contract, and a preliminary design review was held at Warner Robins to evaluate the proposed ISP. Final ISP definition was completed, and then four wings were sealed with the prototype process.

The process used in prototyping the F-15 ISP started with thoroughly cleaning the wing to ensure a good surface for sealant adhesion. The wing tank was then sealer primed, and a fillet seal was applied in areas receiving the spray sealant. As the fillet seals cured, areas that did not require sealing were masked off. When the fillet seals became tack free, seven coats of polysulfide sealant (PR-1750) were applied to a total thickness of approximately 0.070 inch. Each coat of sealant was gradually feathered to span 3 inches on either side of potential leak areas. The upper skin was then installed with a fay surface seal applied to the upper flanges of the inboard structure to provide additional leak protection to this highly leak prone area. The wings were then conventionally sealed with channel groove sealant. Fuel tank maintenance is not affected by the ISP. The wings were placed in service on four separate aircraft and evaluated in a functional environment.

The following groups were essential to the completion of this project: WR-ALC/TI, Robins AFB GA, for providing personnel and facilities to prototype this effort; WR-ALC/LFP, Robins AFB GA, for adjusting the PDM schedule to allow prototyping; WRDC/ALF, Wright-Patterson AFB OH, for getting the project approved; 57th Fighter Wing, Nellis AFB NV and 32nd Fighter Group, Soesterberg AB, The Netherlands, for the use of their planes for this evaluation along with providing the weekly status reports; SM-ALC/TIELE, McClellan AFB CA, for their testing and process information; SM-ALC/LAC, McClellan AFB CA, for lending their expertise from the F-111 spray sealing program; and the 32nd Fighter Group Fuel Shop, Soesterberg AB, The Netherlands, for their great support.

3. TECHNICAL INVESTIGATION

Statement of the Problem

The problem that initiated this project is the chronic leaking of the F-15 wing integral fuel tanks. This leaking causes excessive maintenance hours to be expended in stopping the leaks. Although there are certain areas of the wing that are more prone to leaks than others, the problem is not confined to these areas, and leaks can be found in any area that comes in contact with fuel. These leaks are even more difficult to categorize because of "sneak leaks" (leaks that appear externally in one area but may have started in a distant internal location).

Investigation and Findings

The cause of the problem was identified through the F-15 APG PIWG along with field units contacting F-15 engineering at Robins AFB and stating they were experiencing considerable leaks from the integral wing fuel tank.

The initial investigation into this problem revealed several causes to the problem. One of the major problems found with the F-15 channel groove system was that the technical data available to the technicians was incomplete, inaccurate, and confusing. This led to maintenance-induced problems with the injection of the channel groove sealant, resulting in blown channel grooves and overpressurized seals. Another problem was found to be that the channel groove sealant predominately used in resealing the wing, Dow Corning 94-031, swells at different rates with different fuels, creating serious leaks when fuel other than JP-4 is used. These factors coupled with a highly loaded flexible wing structure produce an environment very susceptible to leaking.

Technical Approach

The initial approach used in attempting to decrease the wing fuel leaks was to test the ISP, which sprayed all potential leak paths with polysulfide sealant thinned with solvent. The thinning was accomplished by adding a solvent blend of methyl ethyl ketone and toluene to the sealant to reduce its viscosity. The ISP required that seven coats be sprayed to build the seal to the required thickness of 0.070 inch.

Although the first approach was successfully prototyped, the application time was excessive, and the benefits of the process would not offset the adverse impact to the F-15 PDM schedule. This process was still used as the proof of concept since all the spraying processes investigated use the same basic principals.

The second approach investigated was the process used in spray sealing F-117s and AC-130 gunships. This approach was not pursued since it involved a proprietary process and would either have to be applied by an outside contractor or the rights to the process would have to be bought. This is not a cost-effective solution because we already possess the organic capability.

The third approach was to investigate the F-111 spray sealing process. This approach used a polythioether that could be sprayed without being thinned.

This process was appealing because it could significantly reduce the ISP application time because only small sections of the tank require fillet sealing and only two spray coats of sealant. Another positive attribute was that less solvent is required because the sealant does not need thinning. One potential drawback is that the sealant is a skin sensitizer, and strict safety, ventilation, and personnel protective equipment requirements must be strictly adhered to.

In parallel efforts conducted by F-15 engineering, the F-15 wing fuel tank sealing technical data has been completely overhauled so that it is less confusing and more user friendly. Also, a process similar to the ISP in which the sealant is brushed on instead of sprayed on was implemented into the F-15 PDM, and an improved channel groove sealant was specified to replace the existing sealant. These changes are anticipated to greatly improve the present sealing system of the F-15 wing fuel tanks.

The technical approach centered on the determination of two key factors: verifying that the ISP could be applied in a production environment and proving that the ISP would significantly reduce leaks.

In determining the producability of the process, two concerns were raised: environmental and bioenvironmental. The environmental concerns that were raised dealt with the volatile organic compounds (VOC) released during the sealing process. An evaluation of the F-15 ISP VOC emission levels was not accomplished. Personnel exposure limits (PEL) to the ISP compounds were of great concern to the Robins AFB bioenvironmental office. A study done by Brooks AFB, Texas, Industrial Hygiene Evaluation of the F-111 Fuel Tank Sealant Process (Report Number: AL-TR-1992-0139), concluded the process could be accomplished efficiently and safely provided personnel protection equipment (PPE) and ventilation requirements are followed. The bioenvironmental requirements placed on the F-15 ISP included having to perform the ISP in a paint booth while meeting TO 42A-1-1 and AFOSH STD 161-2 specifications, along with extensive PPE requirements, none of which is currently required for sealing an F-15 wing.

The findings showed the ISP could be incorporated into the F-15 PDM, but there would be significant cost in meeting environmental and personnel safety concerns along with attempting to allocate a highly specialized facility, i.e., an approved paint booth.

Determination of ISP effectiveness was accomplished by having the using organizations, 32nd FG, Soesterberg AB, The Netherlands, and 57th FW, Nellis AFB, NV, provide weekly status reports to F-15 engineering at Robins AFB. The aircraft were in service approximately 1 year, and the field units reported 22 leak occurrences on the ISP wings and 26 leak occurrences on the conventionally sealed wings. Although only a small percentage of the leaks on the ISP wings was in areas where the ISP was applied, the results did not show the ISP to be superior to conventional sealing. An on-site evaluation of the ISP aircraft was conducted by engineers from both Robins AFB and McDonnell Douglas. An internal evaluation revealed that the sealant had adhered as expected, with no evidence of debonds or sealant degradation. An external evaluation of the wings (aircraft fully fueled) showed that the ISP wings were, on the average, only slightly drier than the conventionally sealed wings.

Conclusions and Recommendations

The in-service evaluations revealed that the ISP did not produce sufficient leak reductions to justify the expense anticipated in meeting the environmental, personnel safety, and facility allocation concerns for process implementation. It is further concluded that the other concurrent efforts provide far greater benefit with very little impact.

It is recommended that the ISP not be implemented into the F-15 wing sealing process.

4. LESSONS LEARNED

F-15 Improved Sealing Process

a. Although the spray sealing technology was a proven technology, the initial approach used for the F-15 ISP was never applied in a production setting. Since the ultimate goal was to apply the process in a production environment, all levels of the production community should be involved from the earliest stages. This may seem obvious, but many technical efforts are never fully coordinated with the end user because of various reasons. Without the support of the production activities, the project will meet with unnecessary hurdles.

The production organization was brought into the F-15 ISP program early for consultation about equipment, facilities, manpower, and scheduling, but this was mainly for the prototyping and not full scale implementation. Their efforts were very helpful in determining the feasibility and impact the process would have. But, not having them "in the loop" after the initial prototyping slowed the implementation process as the details of facilities, schedules, and costs were determined.

b. Another lesson was learned in trying to fix an ill-defined problem. This project was not straightforward because exact leak locations cannot be pinpointed. Specific areas are more prone to leaking, but anywhere on the wing is subject to leaking.

The problem may have been easier to resolve had some type of tracking system been implemented at an early stage in the life cycle of the F-15. Without a good database to use in attacking the problem, the data was received from the experts, the people in the field who work with the system every day.

5. IMPLEMENTATION

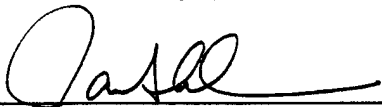

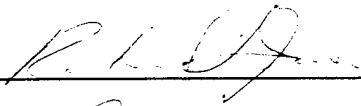

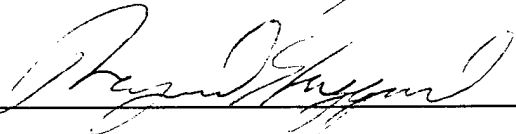
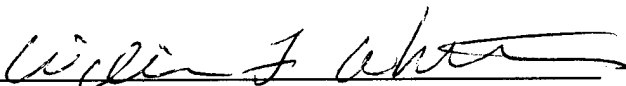
Because of less than desirable results of the testing and the cost associated with implementing this process, it was determined that implementation would not occur.

6. ECONOMIC SUMMARY

PRAM Project Cost: \$152.3K

a. Process development and prototype	\$121.1K
b. Organic manpower and supplies	\$ 18.2K
c. Testing	\$ 6.5K
d. Travel	\$ 6.5K

F-15 Fuel Tank Sealant
PRAM Project

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